Science, Technology and Capital Stock Division

Division des sciences, de la technologie et du stock de capital

Canada

ESTIMATION
OF
RESEARCH AND DEVELOPMENT EXPENDITURES
IN THE HIGHER EDUCATION SECTOR,
1984-85

Science, Technology and
Capital Stock Division,
September 1986.

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cette papier disponible
sur demande.

THIS PROCEDURE REPRESENTS OUR FIFTH
ATTEMPT TO PROVIDE REALISTIC ESTIMATES
OF R&D COSTS IN THE HIGHER EDUCATION SECTOR.
WE WOULD APPRECIATE YOUR COMMENTS
AND SUGGESTIONS.

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Introduction

The Higher Education sector is composed of "all universities, colleges of technology and other institutes of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education establishments."(1)

It is one of the sectors which make up the national research and development(R&D) system. For most policy analyses, the R&D system is sub-divided into five performing sectors: federal government, provincial governments, business enterprises, higher education and private non-profit. It is also sub-divided into six funding sectors: the five above plus all foreign sources. So far as possible, R&D expenditure and personnel data are secured by surveying the performing institutions. There are, however, unusually serious problems to surveying R&D activities in the Higher Education sector. One is that R&D is not normally an organized institutional activity but more of a personal activity of members of the institutions. Institutions in the sector usually have records of funds received by the institution specifically for R&D and some can provide lists of research projects carried out by staff. However, faculty members are expected to perform research as part of their normal duties and neither they, nor their institutions, have any cause to identify the resources devoted to this activity (largely their own time). Surveys of R&D in the sector have not been deemed feasible in most OECD countries because of the lack of records and the number of members performing R&D more-or-less autonomously (in Canada, there are about 35,000 full-time university teachers, 10,000 doctoral students, and an unknown number of part-time teachers and post-doctorate fellovs). Consequently, it is necessary to estimate R&D expenditures by using a model incorporating any relevant data available to us. The pages below describe the method currently used to prepare these estimates.

Selection of institutions at which R&D is performed

Institutions with R&D activities are first identified. This selection is based on reports of payments (grants or contracts) awarded to institutions, or members of these institutions, in support of R&D. These reports may be provided by the performing institutions themselves, mainly through the annual survey of the Canadian Association of University Business Officers (CAUBO), or by funders, mainly federal government departments and agencies providing information on R&D payments to Statistics Canada.

As a result of this review, the following institutions have been identified:

Province	Institution
Newfoundland	Memorial University
Prince Edward Island	University of Prince Edward Island
Nova Scotia	Acadia University
	University College of Cape Breton
	Dalhousie University
	Mount St. Vincent University
	Nova Scotia Agricultural College
	St. Francis Xavier University
	St. Mary's University
	Technical University of Nova Scotia
New Brunswick	Universite de Moncton
	Mount Allison University
	University of New Brunswick
Quebec	Bishop's University
	Concordia University
	Universite Laval
	McGill University
	Universite de Montreal
	Universite du Quebec
	Institut national de la recherche scientifique
	Universite de Sherbrooke
Ontario	Brock University
	Carleton University
	University of Guelph
	Lakehead University
	Laurentian University
	McMaster University

Ontario - concl'd	University of Ottawa
	Queen's University
	Ryerson Polytechnical Institute
	University of Toronto
	Trent University
	University of Waterloo
	University of Western Ontario
	Wilfrid Laurier University
	University of Windsor
	York University
Manitoba	Brandon University
	University of Manitoba
	University of Winnipeg
Saskatchewan	University of Regina
	University of Saskatchewan
Alberta	University of Alberta
	University of Calgary
	University of Lethbridge
British Columbia	University of British Columbia
	Simon Fraser University
	University of Victoria

Distribution of total expenditures by field of science

The estimation of R&D expenditures is based on total university expenditures. Since ve require R&D expenditures by major field of science, the next step is to divide the total expenditures of the listed institutions into these fields.

This distribution is based on the numbers of full-time teachers in the different teaching fields (no information is available on part-time teachers); the data are provided by the Postsecondary Section of the Education, Culture and Tourism Division of Statistics Canada.

Assume that the full-time teachers in one of the above institutions are distributed as follows:

Education	75
Fine and applied arts	50
Humanities	100
Social sciences	250
Agricultural and biological sciences	75
Engineering and applied sciences	75
Health professions	125
Mathematics and physical sciences	150
Total	**900**

Since the number of teachers in each field is used only to distribute total costs, these sub-totals are weighted to reflect the characteristics of the data (such as lack of information on part-time teachers), different consumptions of university resources and different requirements for capital equipment.

Teachers in education, fine and applied arts, the humanities and the social sciences are given a veight of one. To allov for the higher costs per teacher due to the need for more equipment and special facilities, as vell as a slightly different rank and age structure, teachers in the agricultural and biological sciences, engineering and applied sciences, and mathematics and physical sciences are given a weight of two. Because of the extensive use of part-time teachers, as well as the costs of equipment and facilities required for instruction and research in the health sciences, full-time teachers in the health professions are given a veight of 2.5.(2) The above hypothetical example, in terms of distribution of weighted numbers of full-time teachers, vould therefore become:

Teaching field	Weighted No.	Percent of total
Education	75	5
Fine and applied arts	50	4
Humanities	100	7
Social sciences	250	18
Agricultural and biological sciences	150	11
Engineering and applied sciences	150	11
Health professions	312	22
Mathematics and physical sciences	300	22

The field of science percentage distributions, calculated in this manner for each of the listed institutions, are applied to the relevant total costs of each institution. The relevant total costs are total expenditures, excluding costs of "ancillary enterprises", as provided by the CAUBO survey.

Estimation of R&D costs by field of science

This is the most difficult step. One method of estimating these costs is based on the assumption that the relative amount of time spent on R&D by the university staff is representative of the proportion of costs that should be attributed to the activity. Surveys to determine the "time budgets" of faculty members are expensive, difficult and rare. We have, therefore, been compelled to postulate ratios which seem plausible. The situation is complicated by the fact that different teaching fields would have different ratios and that institutions have different degrees of involvement in R&D. For example, analysis of a recent survey by the National Science Foundation indicates that, for the surveyed U.S. institutions, R&D accounts for 22% of the total time of faculty in engineering, 23% for physical scientists, 33% for agricultural and biological scientists, 26% for medical scientists, 8% for psychologists, 8% for social scientists and 6% for mathematicians.(3) A review of the data provided in the CAUBO survey shows that 12 institutions had no sponsored research, that the sponsored R&D expenditures of 34 of the remaining 57 institutions was less than 10% of general operating expenditures, that 6 had sponsored R&D expenditures of 10-19% of general operating expenditures and 17 had R&D expenditure ratios of 20-50%.

In the table which follows, R&D ratios are suggested, based on teaching field and apparent relative institutional effort devoted to R&D.

Teaching field	Small R&D performers	Medium R&D performers	Large R&D performers
Education	.1	.2	.3
Fine and applied arts	-	.1	.2
Humanities	-	.2	.3
Social sciences	.1	.2	.3
Engineering and applied sciences	.1	.25	.35
Agricultural and biological sciences	.1	.25	.35
Health professions	.1	.25	.35
Mathematics and physical sciences	.1	.25	.35

Two points should be made in reply to potential criticisms. Although the table appears to be far too detailed for the amount of "hard" information available, it is almost as easy to apply a variety of ratios in an estimation program as one or two. It also seems to us that the table reflects reality: relatively more time is spent on R&D by faculty in some universities than in others, and R&D is a more important activity in some teaching fields than in others. The exact ratios are impossible to defend but easy to change - if anyone can provide better ones. Examples of the estimates of R&D costs resulting from the use of different ratios are shown in the next section (Models II and III). The second point is that the activity is defined as R&D, which is rather narrower than "research" or "development" in normal usage. Much scholarly activity, from teaching to improving one's own knowledge of a field outside of a research project, is excluded.(4)

In an earlier step, the total costs of each institution were distributed among the eight teaching fields. In the present step, the ratios of the preceding table are applied to these teaching field costs. The ratios in the first column would be applied to institutions at which R&D is a relatively minor activity (typically universities without a doctoral program), those in the second column to universities at which R&D is a more important function, and those in the third column to the universities with large R&D and doctoral programs.

Three models

Three sets of teacher weights and R&D ratios were applied to the same teacher and cost data for those institutions which replied to the 1984-85 CAUBO survey (estimates for one of the listed institutions have to be made separately). In the first model, no weights were applied to the numbers of teachers in each institution. This would be based on the assumption that the different fields make the same relative use of part-time teachers, that their rank/salary patterns are the same, and that each requires the same amount of equipment and other resources. It is also assumed that teachers in the different fields spend the same amount of time in R&D (10% for smaller R&D institutions, 20% for medium R&D institutions, and 30% for larger R&D institutions).

R&D Costs: Model I

Social sciences	$ 654
Health sciences	247
Other natural sciences	367
Total	**1,268 million**

In the second model, the numbers of teachers are weighted to reflect different cost patterns in the teaching fields. The weights used are those used in the earlier sections: one for teachers in education, fine and applied arts, humanities and social sciences; two for teachers in agricultural and biological sciences, engineering and applied sciences, and mathematics and physical sciences; 2.5 for teachers in the health sciences. As in model one, R&D times are assumed to be the same for different fields but to differ by institutional group (i.e., 10% for smaller R&D institutions, etc.).

R&D Costs: Model II

Social sciences	$ 429
Health sciences	375
Other natural sciences	464
Total	**1,268 million**

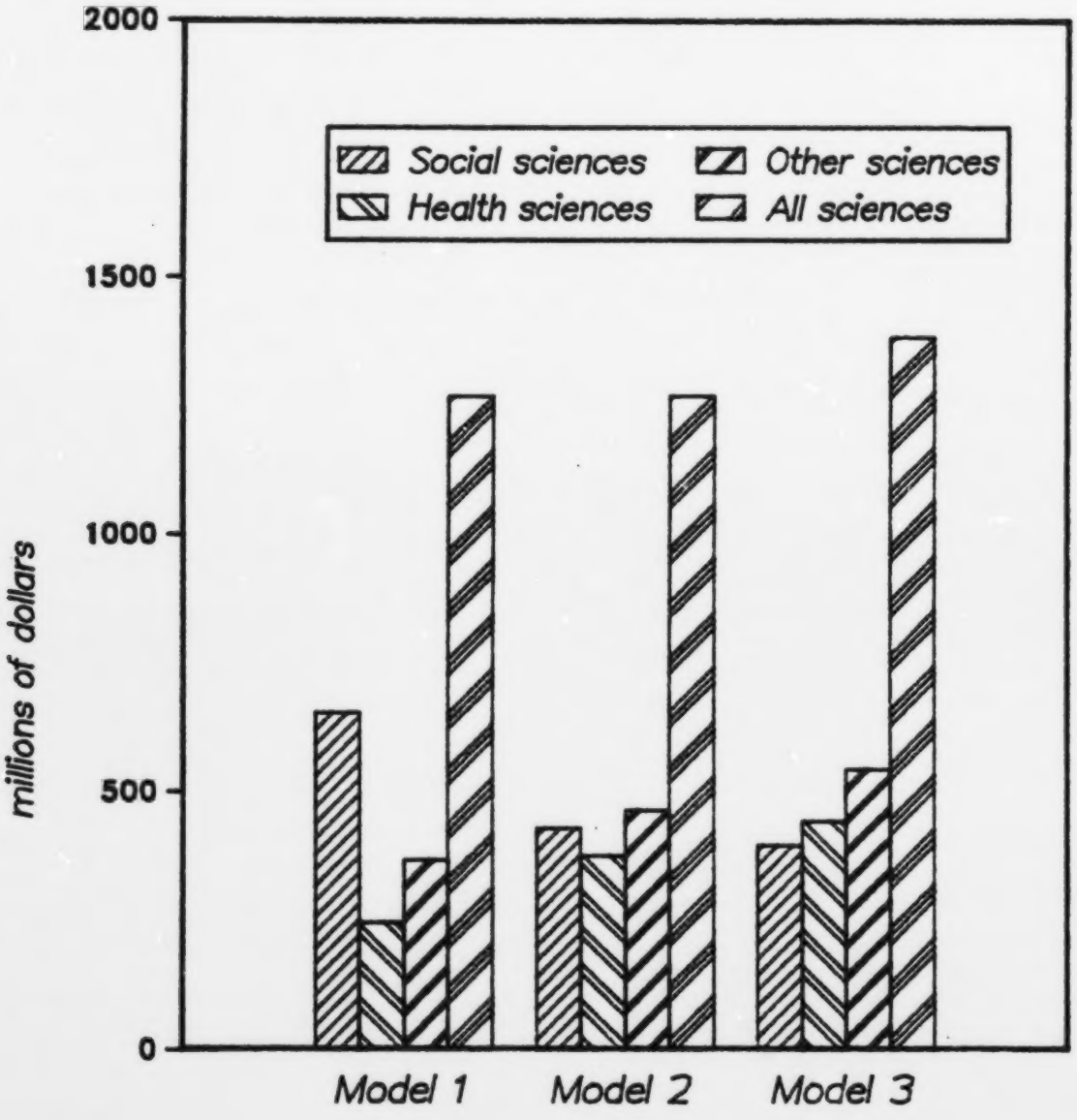
The third model is that used in this note: weighted teacher costs as in model 2 and different R&D ratios for the teaching fields as shown in the table on page 11.

R&D Costs: Model III

Social sciences	$ 396
Health sciences	443
Other natural sciences	543
Total	**1,382 million**

The estimates of R&D costs which would be derived from the three models are shown graphically on the next page.

R&D Costs in the Higher Education Sector, Three Models – 1984–85



Sources of funds for R&D

The sources of funds for academic R&D must nov be estimated. Unfortunately, data exist only for sponsored research. Much R&D is carried out without external funding and hence has no accounting record. Furthermore, university administrations have frequently stated that funds received as R&D grants do not cover the full cost to the university of the R&D carried out. Contracts normally come closer to covering full costs.

While the funding of R&D in U.S. universities will probably differ from the Canadian pattern, U.S. data may indicate the kind of distribution which might occur in Canada. Some relevant statistics are shown below, illustrating the different funding patterns of the teaching fields in the U.S.A.

Item	Physical sciences	Mathematical sciences	Engineering	Life sciences	Social sciences
	hours				
Professional activities(1)	50	41	49	51	48
Of which research	(21)	(10)	(15)	(19)	(11)
	per cent				
Support for research:					
Federal govt.	70	34	69	72	20
Other sponsors	8	6	15	15	16
Unsponsored	22	59	16	13	64

(1) Average number of hours spent in professional activities per week by faculty at doctorate-granting institutions in 1978-79.

Source: NSF 81-317, op. cit.

The pattern shown in the table above seems reasonable: a greater degree of financial support for R&D in the engineering, life and physical sciences and a greater amount of faculty R&D carried out in the same fields, compared to the funding and level of activity in the social and mathematical sciences.

The classification of sources of funds must correspond to the standard sectors in order to permit international comparisons of R&D statistics. In accordance with the recommendations of **A Framework for Measuring Research and Development Expenditures in Canada** (catalogue No. 88-506E), the reports of R&D performing institutions are preferred to those of funders, so we turn initially to the annual CAUBO survey.

The CAUBO survey provides data on sponsored research for participating institutions (47 of the 48 R&D performers). These data are classified as follows:

Federal government:

- Social Sciences and Humanities Research Council
- Health and Welfare Canada
- Natural Sciences and Engineering Research Council
- Medical Research Council
- Other

Provincial governments
Municipal governments
Foreign governments
Gifts, non-government grants
Investment income
Miscellaneous
Interfund transfers

The CAUBO sources can be partially assigned to the six standard sectors:

Federal government	Federal government
Provincial governments	Provincial governments Municipal governments
Foreign	Foreign governments

The problem is to allocate the remaining sponsored research funds ("gifts, non-government grants" - 17% of total funds; "investment income" - 1% of total funds; "miscellaneous income" - 1% of total funds; and "interfund transfers" - 1% of total funds). It is assumed that all these sponsored research funds are derived from the two remaining external sectors: the business enterprise and private non-profit sectors. This is slightly inaccurate because at least some of the funds shown as investment income or interfund transfers come from the higher education sector. However, as indicated above, the amounts cannot be significant. The difference between the total of the funds for sponsored research and the total costs of R&D is attributable to the higher education sector.

Because of the lack of information on R&D funding, the eight major teaching fields must be consolidated into three:

Social sciences and humanities (education, fine and applied arts, humanities, and social sciences),

Health sciences (health professions), and

Other natural sciences and engineering (engineering and applied sciences, agricultural and biological sciences, mathematics and physical sciences).

For each institution, the following model is applied:

Source	Social sciences and humanities	Health sciences	Other natural sciences and engineering	Total
Sponsored research				
Federal government(1)	SSHRC, 30% of remainder	H&WC, MRC 10% of remainder	NSERC, 60% of remainder	CAUBO
Provincial governments(2)	30%	20%	50%	CAUBO
Business enterprises	20%(3)	20%(3)	60%(3)	(4)
Private non-profit	5%(5)	85%(5)	10%(5)	(6)
Foreign	0%(7)	50%(7)	50%(7)	CAUBO
Sub-total	**sum**	**sum**	**sum**	**CAUBO**
Other costs				
Higher education	residual	residual	residual	residual
Total	(8)	(8)	(8)	(8)

See page 18 for footnotes.

(1) The "remainder" is the difference between the Federal government total for university and the amounts attributed to SSHRC, H&WC, MRC and NSERC. Distribution of "remainder" is based on the survey of 1984-85 federal expenditures.
(2) Distribution of the provincial government funds for each university is based on that reported by six provincial governments for 1984-85.
(3) As reported by major universities in the enquiry described below.
(4) An enquiry of members of the Canadian Association of University Research Administrators yielded estimates of R&D payments from business enterprises for 20 universities. These estimates are used for the 20 respondents. These R&D payments amounted to 23% of the total gifts and non-government grants reported to CAUBO for these institutions. A slightly higher ratio (25%) was applied to this source for all other institutions to provide the total business enterprise funding because of the concentration of medical faculties among the
(5) Distribution based on reports by private non-profit organizations. See "R&D Expenditures of Private Non-profit Organizations, 1984", **Science Statistics**, Vol. 9, No. 12, December 1985.
(6) The difference between the business enterprise funding and the total gifts and non-government grants is assigned to the private non-profit sector.
(7) Based on federal obligations for basic research to Canadian performers, as reported in **Federal Funds for Research and Development, Fiscal Years 1983, 1984, and 1985**, NSF 84-336, National Science Foundation, Washington, D.C., 1984, Table C-98.
(8) As estimated earlier.

Looking at the model, it is apparent that the area of uncertainty is basically in the "Other costs" section. The totals of the sponsored research are known from the CAUBO survey and an alternative but still reasonable distribution pattern between fields of science would not make much difference. "Other costs", on the other hand, are the difference between the known funding of sponsored research and the estimated total costs of all R&D in the sector. As this total would change with different assumptions, so would these "other costs".

Special calculations are made for the Institut national de la recherche scientifique, which is not included in the CAUBO statistics. Aggregating all institutions provides an estimate of total R&D expenditures in the higher education sector which may be integrated into the national totals (GERD).

Footnotes

1. **A Framework for Measuring Research and Development Expenditures in Canada**, Catalogue No. 88-506E, Statistics Canada, Ottawa, 1984, p. 18.

2. Examples of R&D cost estimates derived from unweighted numbers of full-time university teachers are presented later in "Model I".

3. **Academic Science/Engineering: Scientists and Engineers, January 1983**, National Science Foundation, Washington, D.C., 1984, p. 16 (Table B-18 divided by Table B-17). Another example of the different field ratios is given in "University S/E Faculty Spend One-Third of Professional Time in Research", Science Resources Studies Highlights, NSF 81-317, National Science Foundation, Washington, D.C., 31 August 1981.

4. See, for example, Chapter 1 of the first reference or **Manual for Statistics on Scientific and Technological Activities**, ST-84/WS/12, Unesco, Paris, June 1984, pp 26-33.

TABLE 1. Total R&D Costs in the Higher Education Sector, by Source of Funds and Major Teaching Field, 1984-85

Source of funds	Social sciences and humanities	Health sciences	Other natural sciences and engineering	Total
	millions of dollars			
Federal government	55	159	303	517
Provincial governments	49	28	91	168
Business enterprises	9	8	29	46
Higher education	280	150	117	547
Private non-profit	7	105	23	135
Foreign	-	5	6	11
Total	**400**	**455**	**569**	**1,424**

TABLE 2. Total R&D Costs in the Higher Education Sector, by Source of Funds, 1979-80 to 1984-85

Source of funds	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
	millions of dollars					
Federal government	234	278	353	393	453	517
Provincial governments	76	96	115	142	153	168
Business enterprises	21	30	33	28	31	46
Higher education	417	472	478	587	567	547
Private non-profit	82	91	105	101	121	135
Foreign	7	8	9	10	11	11
Total	**837**	**975**	**1,093**	**1,261**	**1,341**	**1,424**

In the tables which follow, these estimated national aggregates are distributed by province. The use of a decimal place does not indicate a greater degree of accuracy - it is merely a mathematical convenience because of the number of small amounts which would otherwise disappear with rounding.

TABLE 3. Estimated Costs of R&D in the Social Sciences and Humanities in the Higher Education Sector, by Source of Funds and Province, 1984-85

Province	Federal government	Provincial governments	Business enterprise	Higher education	Private non-profit	Total
	millions of dollars					
Nfld.	1.2	0.2	0.2	5.2	0.2	7.0
P.E.I.	0.2	-	--	0.3	--	0.5
N.S.	1.9	0.1	0.1	7.0	0.1	9.2
N.B.	1.5	0.2	0.1	5.5	0.1	7.4
Que.	14.7	17.1	2.1	45.0	1.8	80.7
Ont.	22.8	12.4	4.5	133.8	3.2	176.7
Man.	2.7	1.2	0.4	13.1	0.3	17.7
Sask.	1.4	1.7	0.3	6.8	0.1	10.3
Alta.	2.7	14.5	0.7	39.0	0.5	57.4
B.C.	6.3	1.8	0.7	23.8	0.6	33.2
Canada	**55.4**	**49.2**	**9.1**	**279.5**	**6.9**	**400.1**

"-" = nil.
"--" = less than $0.05 million.

TABLE 4. Estimated Costs of R&D in the Social Sciences and Humanities in the Higher Education Sector, by Province, 1979-80 to 1984-85

Province	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
	millions of dollars					
Nfld.	5	6	6	6	7	7
P.E.I.	--	--	--	--	--	1
N.S.	7	7	8	8	9	9
N.B.	4	5	6	7	7	7
Que.	57	60	67	73	75	81
Ont.	108	121	134	155	170	177
Man.	10	12	13	15	17	18
Sask.	7	8	7	9	9	10
Alta.	32	39	45	57	55	57
B.C.	23	29	32	34	34	33
Canada	**253**	**287**	**318**	**364**	**383**	**400**

"--" = less than $0.5 million.

TABLE 5. Estimated Costs of R&D in the Health Sciences in the Higher Education Sector, by Source of Funds and Province, 1984-85

Province	Federal government	Provincial governments	Business enterprise	Higher education	Private non-profit	Foreign	Total
	millions of dollars						
Nfld.	2.3	0.2	0.2	1.6	3.1	--	7.4
P.E.I.	--	-	-	-	-	-	--
N.S.	6.5	--	0.1	8.5	2.1	0.3	17.5
N.B.	0.5	0.2	0.1	--	1.5	-	2.3
Que.	44.7	10.7	2.0	14.7	26.1	0.5	98.7
Ont.	60.9	4.2	3.9	59.5	48.1	2.7	179.3
Man.	10.5	0.8	0.4	9.6	5.2	0.3	26.8
Sask.	5.0	1.1	0.2	9.6	1.6	-	17.5
Alta.	13.2	9.6	0.7	33.1	8.2	0.1	64.9
B.C.	15.5	1.2	0.6	13.7	9.4	0.7	41.1
Canada	**159.1**	**28.0**	**8.2**	**150.3**	**105.3**	**4.6**	**455.5**

"-" = nil.
"--" = less than $0.05 million.

TABLE 6. Estimated Costs of R&D in the Health Sciences in the Higher Education Sector, by Province, 1979-80 to 1984-85

Province	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
	millions of dollars					
Nfld.	4	6	6	7	7	7
P.E.I.	-	-	-	-	--	--
N.S.	12	14	15	14	16	18
N.B.	1	2	2	2	2	2
Que.	59	70	78	86	90	99
Ont.	94	113	128	149	168	179
Man.	16	17	19	23	26	27
Sask.	10	13	12	15	16	18
Alta.	29	36	43	58	60	65
B.C.	23	31	35	38	39	41
Canada	**248**	**302**	**338**	**392**	**424**	**456**

"-" = nil.
"--" = less than $0.5 million.

TABLE 7. Estimated Costs of R&D in the Natural Sciences and Engineering(1), in the Higher Education Sector, by Source of Funds and Province, 1984-85

Province	Federal government	Provincial governments	Business enterprise	Higher education	Private non-profit	Foreign	Total
	millions of dollars						
Nfld.	9.2	0.5	1.0	4.1	3.5	-	18.3
P.E.I.	0.2	-	--	0.3	0.1	-	0.6
N.S.	20.9	0.6	0.5	12.5	2.5	0.6	37.6
N.B.	6.9	0.6	0.5	5.7	1.8	-	15.5
Que.	105.7	43.7	8.5	45.0	31.4	1.6	235.9
Ont.	188.7	28.9	17.9	95.7	60.0	6.5	397.7
Man.	22.5	2.7	1.5	21.2	6.0	0.6	54.5
Sask.	18.9	4.0	1.1	9.7	2.1	-	35.8
Alta.	37.8	33.8	2.8	51.8	9.2	0.3	135.7
B.C.	51.2	4.3	2.7	21.6	11.2	1.4	92.4
Canada	**462.0**	**119.1**	**36.5**	**267.6**	**127.8**	**11.0**	**1,024.0**

(1) Includes health and other natural sciences and engineering.
"-" = nil.
"--" = less than $0.05 million.

TABLE 8. Estimated Costs of R&D in the Natural Sciences and Engineering(1), in the Higher Education Sector, by Province, 1979-80 to 1984-85

Province	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
	millions of dollars					
Nfld.	12	14	15	18	18	18
P.E.I.	--	--	1	1	1	1
N.S.	21	24	30	29	33	38
N.B.	8	11	11	13	14	15
Que.	147	168	189	206	214	236
Ont.	222	256	289	338	377	398
Man.	31	33	39	46	52	54
Sask.	21	26	24	30	32	36
Alta.	67	85	99	130	129	136
B.C.	55	71	78	86	88	92
Canada	**584**	**688**	**775**	**897**	**958**	**1,024**

(1) Includes health and other natural sciences and engineering.
"--" = less than $0.5 million.